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[redacted] STAT

28 November 1972

Dr. Jack Martin
Executive Office of the President
Office of Science and Technology
Washington, D. C. 20506

Dear Dr. Martin:

Evidentally, the enclosed item got seperated from the classified package we sent over to you.

Our meeting with EPA, OCE, 213, etc.-is set for Thursday, 30 November at 10:30 at our facility. We could give a similar pitch to ARGO, if necessary, or at any level you want, if so desired.

Sincerely,

[redacted] STAT

Manager

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APPROACH TO
EPA LAKE SURVEY PROGRAM

1. BACKGROUND

[redacted] has investigated practical methods for obtaining land use and pollutant source data for use in EPA's Lake Eutrophication Survey. To date a lake location survey has been performed, sample output prepared, and a small pilot effort conducted using suggested source material and proposed techniques. As a result of the latter it was necessary to formulate new technical procedures, as will be discussed later. STAT

The general nature of the proposed effort will now be briefly summarized.

- EPA REQUIREMENTS

  Land use delineation and area measurement - pollutant point source identification and location, to be used as input to eutrophication model.

[redacted] APPROACH 25X1

  Use best available aerial photography as information base believed to be small scale synoptic military coverage) - use PI and photogrammetric techniques to acquire desired data - key all output to a civil map.

  Synthesized Data Base:

  Lake Survey File - Lists all lakes in survey, geo. coord., small scale maps, STORET data sheets.

  State File - All lakes in survey for that state, pertinent maps, other collateral data.

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Lake Dossier - Contains following:

- EPA File No.
- State and Lake Name
- Geo. Coordinates (Ctr. Inlet, Outlet).
- Municipalities w/Impact on Lake (from STORET).
- Map References (Location of Maps in Other Files).
- Data Sheet - Quantitative Results of PI Effort.
- Topo Map of Drainage Basin.
- Photos, Imagery and Coverage Plots (if any).
- Overlay of PI Effort Keyed to Topo Map.

PI Categories:

Land Use:

1. Agriculture
   a. Fertilized Cropland
   b. Pasture
   c. Pasture or Cropland
   d. Cleared Unproductive
2. Forest
   a. Forest
   b. Mixed
3. Urban
   a. Intensive
   b. Medium
   c. Low
   d. Maintained Open

Point Sources:

1. Industrial
2. Municipal
3. Agricultural
4. Other

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2. PILOT PROJECT

A pilot effort was performed to evaluate the proposed technical approach and to prepare further briefing materials. The work flow originally proposed follows:

1. Collect material (photos, maps), delineate drainage basin.
2. PI effort using B&L Zoom Transfer Scope to produce in one step overlay keyed to civil map.
3. Measure overlap areas using planimeter measure point coordinates.
4. Smooth plot.
5. Prepare lake dossier.

The B&L Zoom Transfer Scope was a critical element in the work plan, allowing the PI to go directly from the source material to the base map. The device optically superimposes two images, with scale matching and image rotation features. An anamorphic lens permits image stretch in any one direction. It was found upon use, however, that the ZTS was inadequate for the proposed effort. First, the optics so degraded the source material image quality that direct land use interpretation became very difficult. Optical design and illumination made image matching difficult, and matches could only be achieved over a very small field. Also, certain human engineering design features made the work tedious and cumbersome. Output was finally achieved performing the interpretation on a large screen rear projection viewer and then transferring that line overlay to the map base using the B&L ZTS. Those results are presented in a separate attachment. It was concluded that although with modifications the proposed technical approach could be used, results would be rather poor and the labor cost would be sharply increased above original estimates.

Sanitized Copy Approved for Release 2010/03/18 : CIA-RDP80T01137A000300050001-2

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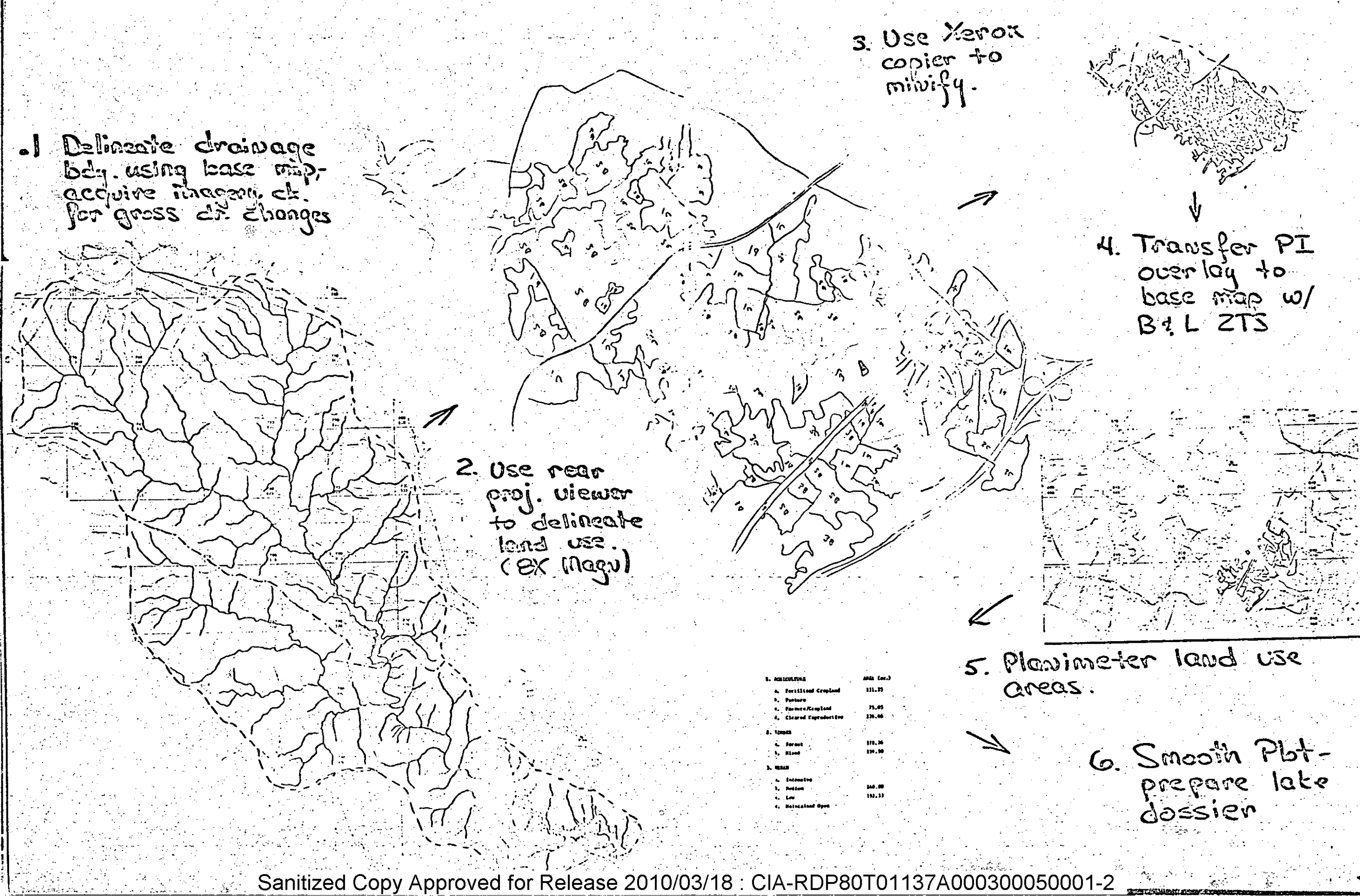
PILOT PROJECT - EPA LAKE SURVEY



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3. REVISED TECHNICAL APPROACH

Two alternative technical approaches have been devised as outlined below:

Optical Rectification

1. Acquire imagery.
2. Reduce imagery to compatible input scale.
3. Rectify.
4. Perform PI effort using pantograph to produce a plot at desired scale.
5. Measure areas with planimeter.
6. Prepare dossier.

Digital Rectification

1. Acquire imagery.
2. Perform PI effort and digitize.
3. Digitally rectify producing both drive tape and area and coordinate measurements.
4. Plot at map scale.
5. Prepare dossier.

Note that neither suggested approach will produce a line overlay that will be a perfect map fit. However, the map match should be adequate for both field and office use. All hardware needed for the optical rectification method are currently available requiring no major R&D effort. Digital rectification requires hardware acquisition and some software development, but is more cost effective.

3.1 Optical Rectification

The suggested source material may be optically rectified using equipment available to the DMA Topographic Center. The same equipment is held by other government agencies. There will be some modifications necessary to existing procedures to allow this rectifier to be used with the source material, but this should present no severe difficulty. The procedure would be to perform a linear scale reduction of the imagery before rectification. The imagery would then be rectified in the normal manner. Because the rectifier will not accommodate imagery beyond certain acquisition formats, any imagery outside of that limit will then have to be rectified with a frame

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rectifier to the vertical. Since the rectified output will be reduced from original scale, it must next be enlarged. Land use interpretation will be performed on a light table with magnifier optics using a cursor attached to a pantograph to produce a real time plot as desired scale. Land use areas would then be determined by planimetry. The main advantage of optical rectification is that all hardware and techniques are now in production use. The EPA program could begin as soon as desired. Unfavorable features include the image degradation resulting from multi-state photo work, and forced reliance on a production shop that owes first consideration to its own work.

3.2 Digital Rectification

Digital rectification is a more direct means for fitting source derived data to a map base, omitting the photo steps and manual planimetry of the optical rectification method. The procedure would be to digitize the land use data from the original photography, being careful that all areas were included. This digital information would then be rectified using a rectification computer program, and the resulting output would be plotted at essentially base map scale. A simultaneous output of the rectification program would be the areas of the various land use regions and point coordinates. The digital rectification program itself would consist of a program to rectify panoramic photography taken at nominally correct orientation and exposure station to zero ground elevation. The effect of relief displacement upon the results of the land use study would be small enough to be lost in the noise of the data, and thus requires no compensation.

It is estimated that the necessary computer programming effort for this task could be accomplished for approximately 7K. It would require approximately two man months of effort. There is virtually no developmental risk involved, as the rectification techniques are already developed to an operational extent in other applications. Hardware costs would be 100-150K for digitizing table, computer and plotter.

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Advantages of this method are self-evident: no image quality is lost, work process is self-sufficient with no reliance upon outside parties, and labor effort is reduced both in plotting and area measurement. Any disadvantage would be the necessity for minor software development and hardware acquisition.

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ESTIMATED COST - EPA LAKE SURVEY

I. Optical Rectification ~ $2.10 per sq. mi.

Assumptions:	All photo work GFE
Hardware Reqrs:	Modified pantographs, planimeters, misc. PI equipment ~ $5K.

II. Digital Rectification ~ $1.60 per sq. mi.

Assumptions:	Required photo work GFE
Software:	Minor programming ~ $7K.
Hardware Reqrs:	Digitizer, plotter, computer ~ $100-150K per unit.

Sanitized Copy Approved for Release 2010/03/18 : CIA-RDP80T01137A000300050001-2

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THE PLOT QUICKENS

Instrument-Aided Graphic Data Plotting and Correlation

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PLOTTING PROBLEMS?

If you are involved in plotting large amounts of aerial photographic coverage or other interpreted data, the odds are that you are not plotting it nearly as fast as you would like to, isn't that right? Either the imagery is coming in too fast or your staff just isn't large enough, but whatever the reason, your schedule slips a little, and then a little more, and the unplotted imagery piles up higher. If this is your problem, maybe [redacted] can help you. But first, let's take a STAT close look at the causes of the problem.

In the current operation of manual plotting and/or cataloging, by far the most time-consuming phase is that of determining the specific geographic coverage of the film or of the thematic data such as soils or land use that is annotated on the film. The principal factor influencing the difficulty of the operation is the character of the terrain that is covered, which may be urban or rural, farm or forest, replete with unique cultural or geomorphic features... or as bland or blank as a desert. But whatever the nature of the terrain, the task of the manual plotter is the same - to make a painstaking search of his map reference and the photography until he finds some feature that is mutually recognizable, and then to plot the data or the photo coverage, repeating this process frame by frame until he comes to the end of the roll. It is no wonder, then, using this conventional, manual, repetitive process, that problems pile up, canisters of unplotted film accumulate, and your data bank becomes dated.

What is the answer? Some kind of automated plotting device? Sorry, not yet. We've explored in that direction only to arrive at the conclusion that, no matter how sophisticated the map correlation method (for example, electro-optical processing, holography, digital map matching, high powered mathematical concepts, or whatever), the general bulk of reconnaissance imagery cannot be automatically turned into the format of standard reference maps. The simple fact is that a line map is usually compiled by having a man extract it from aerial photography. Therefore, it occurred to us, the most practical approach to pursue in trying to bring the two "map" presentations together for correlation is to have the human accomplish the same process of converting photography to a map-like presentation when he is attempting to plot such imagery on a reference map, and, if possible, to design some hardware to speed up the process. In this way, one can take advantage of the tremendous filtering, extrapolating,

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and exploiting capacity of the human interpreter as well as of the great speed, persistence and memory potential of the machine.

THE PLOT QUICKENS

With this as a starting point, the [redacted] has developed the concept of a mechanical aid to the human interpreter in performing plotting and other data bank maintenance tasks. Basically, under this approach, the computer performs all of the mundane tasks of keeping track of the data content of the reference maps, and performing image scale variations, orientation searches, precision mensuration, cataloging, inventorying, cross-correlating, and up-dating. The routine tabulation of associated identification nomenclature (mission number, frame number, overlap, etc.) is also stored for the final output device, which will automatically trace the image outlines, flight paths and annotated data to whatever scale is desired. STAT

This is quickly and easily done by using a cursor or tracing device to feed into a compatible digital storage unit. Under the [redacted] scheme, the interpreter, using the appropriate cursor, quickly traces out obvious cultural or natural features such as roads or rivers, and the resulting trace data is appropriately encoded by key-board entries. In practice, of course, only the digitized equivalents of these data are recorded within the system. STAT

To simplify these data, a scheme was conceived whereby a road is replaced by several points with vectors indicating the direction in which the road (or stream or power line, etc.), runs from a given point. For features which have no intersections shown on the image, individual, spaced vectors are recorded. In practice, of course, the computer is fed the raw trace data via a digitizing cursor, and the transformation into vectors is done internally.

In summary, it is felt by [redacted] that the development and implementation of the basic concept described above will both greatly expedite the overall plotting and data bank maintenance operation and allow the plotting of each frame of imagery and of interpreted thematic data to be consistently accomplished with much higher accuracy than is presently obtained. STAT

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BUT WILL IT FLY?

The next consideration is the practicality of the concept from an instrumentation standpoint. The major components in such a system are a digitizing light table; a central processing unit; some type of reference preparation, storage and retrieval device; and, finally, an output device to physically plot the data that the system generates. Such individual components are commercially available, but stringing together several to form a system doesn't quite solve the problem. The pieced-together collection often is so inflexible that it contributes more complexity to the operation. In a recent hardware development program, [redacted] has fabricated several customized STAT hardware systems, each specifically designed to address particular user needs. The enclosed photograph shows the actual hardware. This system, which in addition to the digitizing light table mechanism, is equipped with several keyboard functions for input of frame descriptors, as well as a numerical counter to verify the correctness of the frame identification data, and a storage tube display to show the operator just what he has traced with his cursor. Various other capabilities are inherent in this system, including frame registration markers and a teletype associated with the computation unit to allow a close man-machine interchange.

WHAT DOES IT DO FOR AN ENCORE?

What you have just read is as brief a description as we could come up with to adequately describe to you the merits and operational rationale of the [redacted] STAT plotting concept. But brevity, for all its good qualities, is apt to obscure the ramifications of possibilities inherent in the basic concept. For example, you may be thinking just now, "O.K., here's a system that gives me a semi-automated way to plot my imagery and keep my data bank up to date. Great, but what else will it do?"

We're happy you asked.

- It will allow you to transfer interpreted thematic data from photo to map, quickly and accurately.
- You may want to use it for mission evaluation or as a pilot training aid. It will evaluate the mission by graphically showing you flight line fidelity, and by reading out the degree of tip or tilt, and the percent of overlap.

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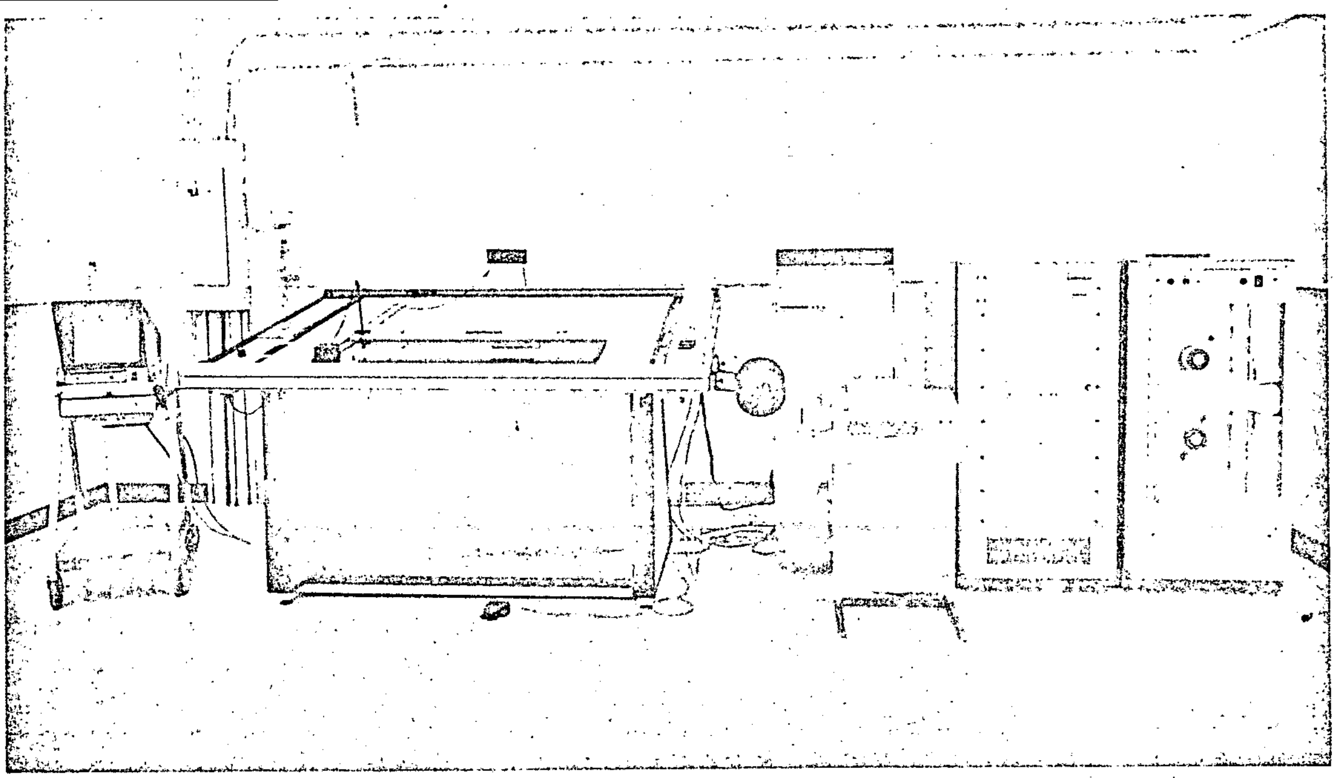

On-Line Graphic Digitizing System

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- It will calculate aerial coverage of any type of annotated data, as well as record the coordinates of the area being considered.
- It will expedite all activities relating to your data bank function, including automatic cataloging, cross-correlating, retrieving, up-dating and inventorying.
- It will work with poor or partly cloud-covered imagery, imagery that might stump the unaided man.
- And, oh yes, it also works with side-looking radar, infrared, etc., any image-forming sensor record.

Anything else? Well, that's all we've thought of so far, but if you have any questions, why not call us and ask.

A FINAL WORD

Why does [redacted] feel competent to solve your plotting and data bank problems? Well, we've been in the remote sensing and reconnaissance business for thirteen years, and in that time we've designed and operated data banks and plotted thousands of rolls of imagery on many thousands of square feet of maps -- imagery from customers in the military, in government, and in private industry. We've worked with the imagery formats of every kind of remote sensor, from SLAR and IR to microwave and laser. In other words, we've had the same plotting problems that you have. The only difference is that we are lucky enough to have physicists and engineers on our staff to solve them for us. Let us solve them for you, too.

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